CARL T. JONES CORPORATION

March 1, 1994

Mr. William F. Caton, Acting Secretary
Federal Communications Commission
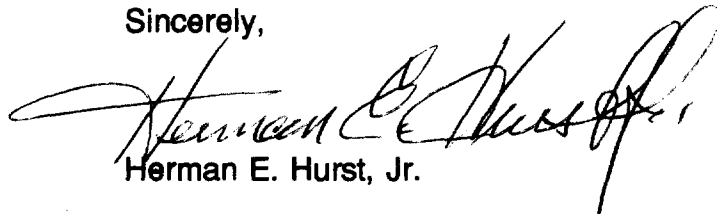1919 M Street, N.W.
Washington, DC 20554

Re: MM Docket No. 93-177

Dear Mr. Caton:

     Enclosed is the original signature copy and four additional copies of the Reply Comments of Carl T. Jones Corporation in the Matter of an Inquiry into the Commission's Policies and Rules regarding AM Radio Service Directional Antenna Performance Verification.

     If there are questions regarding these Reply Comments, please contact the undersigned.
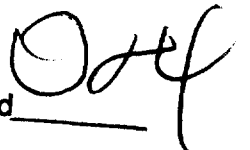
Sincerely,

Herman E. Hurst, Jr.

HEH/law

Enclosures

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of

An Inquiry into the Commission's	)	MM DOCKET NO. 93-177
Policies and Rules Regarding AM	)	RM-7594
Radio Service Directional Antenna	)	
Performance Verification	)	

REPLY COMMENTS OF CARL T. JONES CORPORATION
FCC NOTICE OF INQUIRY

Carl T. Jones Corporation is a communications consulting engineering company.

The firm, founded by John H. Barron in 1935, has provided engineering services to the

broadcast industry for the past 58 years. Carl T. Jones Corporation (CTJC) herein

submits its Reply Comments in the above captioned Notice of Inquiry. On October 29,

1993, CTJC submitted comments in this proceeding. We have reviewed Comments filed

by the seventeen (17) other interested parties. Based on the technical issues raised and

proposals for Rule changes advanced by the other Commentors, we have developed the

following Reply.

INTRODUCTION

By Notice of Inquiry (NOI) adopted June 14, 1993, released June 29, 1993, the

Commission initiated action seeking to revise and update its technical rules governing

measurement, monitoring, and verification of compliance with authorization of AM

directional antenna systems. The NOI was adopted in response to a Petition for Rulemaking submitted by five technical consulting firms[1] ("the petitioners") eminently experienced in the design and adjustment of AM directional antenna systems. While the NOI focused particularly on directional antenna array performance verification methodology, it invited comment on all aspects of the present Rules and Regulations governing AM transmission equipment and systems.

GENERAL MATTERS

We initially take issue with several Commentors' claim that many directional antenna systems are out of adjustment. Further, it is claimed that licensees knowingly avoid compliance since potential fines levied by the Commission are not as costly as the expense associated with bringing the array into compliance. While such situations certainly exist, based on our direct experience with broadcasters throughout the country, we do not believe such practice to be widespread, rather the exception. In fact, we find that the vast majority of broadcasters diligently work to insure compliance with the Commission's technical regulations.

Also, we are concerned that major changes in technical regulations today will prove to be short-sighted in light of the Rule revision process which will inevitably follow adoption of Digital Audio Radio (DAR) transmission standards. Should the new standards provide for in-band AM DAR, we foresee major AM Rule revisions. These revisions will

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[1] The firms of du Treil, Lundin & Rackley, Inc.; Hatfield & Dawson Consulting Engineers, Inc.; Lahm, Suffa & Cavell, Inc.; Moffet, Larson & Johnson, Inc.; and Silliman & Silliman jointly filed on December 14, 1989.

relate directly on the matters under consideration in this Docket. We envision that in-band DAR standards will include:

1) new co-channel and adjacent channel interference protection ratios resulting in allocation criteria revisions. Therefore, any new AM allotment plan could be developed with sufficient margin to accommodate directional transmitting antenna adjustment verification procedures having reduced field measurement requirements.

2) Transmitting antenna technical changes due to bandpass deficiencies with existing antenna systems such as standardized antenna electrical heights to minimize base impedance transformation ratios and/or simplified arrays to minimize sideband pattern distortion.

Upon review of comments filed by other parties, we believe some revision of the current standards is warranted. Accordingly, it is respectfully requested that the Commission consider the following recommendations:

ANTENNA SYSTEM EQUIPMENT

Several aspects of the technical rules dealing with transmission equipment and operation warrant further consideration.

1) Many Commentors have addressed the operational problems associated with the present requirement to maintain base current ratios within specified tolerance of licensed values. Some Commentors have suggested that it is no longer necessary to measure base current values and have recommended

deletion of this requirement. It is sound engineering practice to be able to measure base current values to insure that the power summation of the elements within the array approximates the desired level, thereby insuring excessive losses are not present within the system. On the other hand, since base current values are subject to variation due to environmental factors, they are not necessarily indicative of array pattern performance. Therefore, we agree with Commentors who feel that the requirement to maintain base current ratios is unnecessary and often counterproductive to maintaining compliant directional antenna patterns. Consequently, we recommend that the Commission continue to require the ability to measure base current and the filing of base current values in license applications but delete base current ratios as a specified parameter on a station's license.

2) CTJC also recommends that detailed minimum standards for antenna sampling systems be restored to Section 73.68 of the Rules. These standards should be similar to the standards adopted in 1976. While the standards are still incorporated by inference only, many engineers are confused regarding the actual requirements. A rulemaking proceeding looking toward reinstitution of the technical standards should address any revisions to the prior standards which may be desirable due to recent changes in equipment or technology.

3) CTJC supports the proposal set forth by Cohen, Dippell & Everist to reduce the present transmitter frequency tolerance of 20 Hz to a 10 Hz tolerance to

reduce inadvertent activation of the pilot detection circuitry in some AM stereo receivers.

DIRECTIONAL ANTENNA SYSTEM VERIFICATION

A number of Commentors have advocated the use of computer modeling to replace field strength measurements in the antenna system verification process. These Commentors generally suggest that a combination of currently available models and a more accurate sampling system are sufficient for performance verification of complex directional antenna systems and the environment in which they operate.

Although we support reducing the broadcaster's costs in the antenna system verification process, we believe that such changes, at this time, will result in an overall degradation in service and ultimately damage the AM broadcast service.

Computer models such as the Numerical Electromagnetic Code (NEC) have been in use for many years and have seen increasing use by engineers in modeling MF antenna arrays. This firm, as well as others, have used various versions of the NEC model, as a tool, in predicting the performance of directional arrays and in predicting the effects of certain elements of the environment on the directional antenna pattern.

The use of these models as a design and/or analysis tool to gain insight into the performance of a complex system, such as an AM directional antenna array, can be a cost effective mechanism in the adjustment process. The use of these models as a final verification tool, on the other hand, is inappropriate and unsound for two primary reasons: 1) the engineer cannot accurately and cost effectively define all of the input parameters

associated with each unique antenna system and its surrounding environment, and 2) currently available versions of the NEC model have a number of flaws which lead to errors in the prediction of driving point impedances and ultimately field strength.

Further drawbacks to any effort to verify array performance through internal measurements, determined by an antenna sampling system, are the anomalies, inconsistencies, and inaccuracies present in the monitoring subsystem. In an effort to evaluate sampling system performance, we reviewed the specification sheet accompanying Program Test Authorization for 91 AM stations filing full Proofs-of-Performance during the 1989 - 1993 period. Attachment A sets forth the information gathered showing variances with theoretical parameters for several categories of arrays. While the result of the evaluation is interesting, the only conclusion we reach is that present sample systems do not always define the actual pattern produced by the array. Of course, to date this has not been the function of the sampling system. Rather, its purpose is to measure relative changes which occur in an array. Consequently, we believe that verification of array performance without field strength measurements will always be of questionable accuracy.

The bottom line is that currently available models and engineering techniques for predicting antenna performance are not of sufficient accuracy to be used solely to insure that interference protection will be afforded to other co-channel and adjacent channel stations. The Commission's goal in revising the AM Rules, just two years ago, was to alleviate the interference condition which has plagued AM broadcasters. In that proceeding the Commission adopted tighter interference protection criteria and opened

an expanded AM band for migration by existing stations, for the express purpose of reducing interference in the present AM band. We believe that adoption of Rules for antenna system verification which rely solely on modeling, is contrary to the FCC's stated goal of reducing interference and will ultimately degrade AM service rather than improve it. To continue to protect against increased interference, the Commission must, at this time, reject such a radical departure from its present directional antenna system verification procedures.

In the alternative, what cost saving procedures can be adopted in the area of antenna system verification? We propose several revisions to the Rules, which when considered cumulatively, result in a significant cost savings to the broadcaster without jeopardizing the integrity of the AM service.

We propose reducing the total number of measurements required to be performed in a full proof-of-performance and reducing the quantity of data to be submitted to the Commission when filing a license application for a directional antenna system. We also propose modifying the procedures for measuring monitor points in order to eliminate seasonal effects upon monitor point field strengths often requiring additional partial proofs-of-performance.

The FCC currently requires licensees and permittees of AM directional antenna systems to perform and submit a full proof-of-performance prior to granting a license for a new or modified facility. The FCC requires that both a nondirectional and directional full proof-of-performance be performed, to include monitored radials as specified by the

FCC, as well as, a sufficient number of other radials to insure proper pattern shape and efficiency (a minimum of eight radials).

The primary purpose of the nondirectional field strength measurements is to establish a baseline set of data from which the directional measurements can be accurately analyzed. Through graphical analysis of the nondirectional data, ground conductivity can be established, as well as, the efficiency of the nondirectional radiator along the selected bearing.

In establishing the efficiency, the measured field strengths within the first few kilometers of the station (close-in measured field strengths) are extremely important in that these measurements are least affected by ground conductivity. Many times these measurements are also the most difficult and time consuming to obtain, due to lack of vehicular access to a sufficient number of locations.

For a properly detuned antenna system, the nondirectional efficiency between radials varies no more than ±10 percent. If data were submitted with the proof-of-performance to demonstrate that the unused antennas in the array were properly detuned, then the efficiency could be determined, with the necessary degree of accuracy, from only a few radials, negating the requirement to perform close-in field strength measurements on all nondirectional radials.

We propose that the relative current magnitude, as measured at the current loop of the radiator, be used to establish the degree of detuning of the unused towers and that the relative current of any unused tower not exceed 5 percent of the current on the active element. Further, we propose that close-in nondirectional measurements be limited to

the specified monitored radials and one additional radial in the major lobe at the pattern maxima. The efficiency of all other radials will be assumed to be the average efficiency on these radials. Measurement of nondirectional field strengths on all other radials will be performed only at distances greater than 3 kilometers.

We propose to reduce the number of radials required to be measured as part of a full proof-of-performance. We propose that the following radials be measured: 1) monitored radials as specified by the Commission on the instrument of authorization, 2) all other pattern minima, and 3) one additional radial in the main lobe at the pattern maxima. As a general practice engineers may want to make additional measurements to assist in the adjustment process, however, this minimum set of data, we feel to be sufficient to insure compliance with the station's authorization.

We do not agree with those Commentors advocating deleting those portions of the Rules pertaining to monitoring points, although we do agree that monitor point values can change dramatically with seasonal variation. Seasonal variation can result in out-of-tolerance monitor point readings for a directional array which may otherwise be in adjustment. Since under the circumstance of seasonal variation, both nondirectional and directional field strengths vary proportionally, we propose that both directional and nondirectional measurements be performed at the monitor point and that the station license reflect a maximum allowable ratio of the directional to nondirectional readings. This new parameter fully accounts for the seasonal variation while at the same time providing a good indication of the pattern performance.

We propose this new technique of measuring both directional and nondirectional field strengths at the monitoring points as an option. Stations which do not currently have a means to switch to a nondirectional mode of operation could continue to be licensed for a maximum directional field strength at the monitoring points.
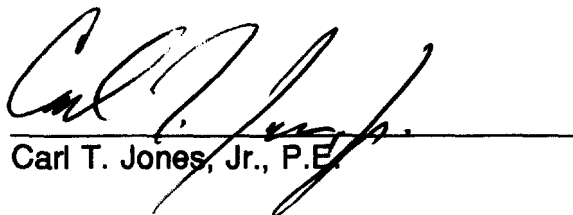
Along with the reduced measurement requirements proposed above, additional cost savings can be realized by the following reduction in data requirements for full Proofs-of-Performance:

   a) Tabulations of measurement data should include point number, distance from antenna, measured non-directional and directional field strength, and the resulting field strength ratio. The engineer's narrative statement should describe the period of the measurement effort by inclusive dates to insure that all measurements were conducted under similar environmental conditions.

   b) Graphic display of only the nondirectional measurements should be submitted. Analysis of the directional measurement data should be by ratio (arithmetic or logarithmic) only.

   c) Only impedance measurement data made at the carrier frequency need be submitted, and records of sideband frequency impedance measurements need not be maintained.

   d) Maps depicting measurement locations should be submitted unless the engineer elects to describe each location by coordinates determined by GPS and includes such data in the measurement tabulations.
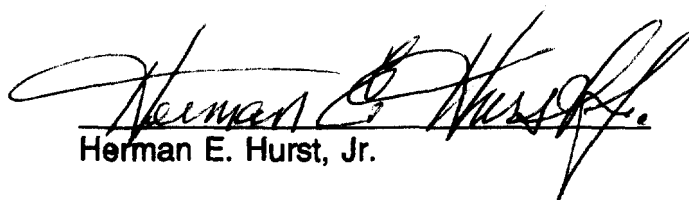
SUMMARY

CTJC respectfully submits that the Rules and Regulations changes proposed above will provide cost savings in the antenna system verification process without increasing the potential for interference between AM stations.

DATED: March 1, 1994

Carl T. Jones, Jr., P.E.

Herman E. Hurst, Jr.

ATTACHMENT A

2-TOWER SAMPLE POPULATION

STATION CALL	ARRAY NOTE*	TOWER NUMBER	TOWER HEIGHT	PHASE DATA (DEGREES)				FIELD DATA			
				THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE	THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE
KIXL	A	1	85.20	0.00	0.00	0.00	14.00	1.000	1.000		2.00%
(night)		4		40.00	26.00	14.00		0.500	0.510	2.00%	
KSSA	A	1	111.30	0.00	0.00	0.00	11.50	1.000	1.000		5.81%
(day)		2		36.50	25.00	11.50		0.860	0.910	5.81%	
WJJD	A	1	93.50	0.00	0.00	0.00	4.00	1.000	1.000		32.22%
(day)		2		-111.00	-107.00	4.00		0.450	0.305	32.22%	
KXL	C	1	90.00	0.00	0.00	0.00	1.00	1.000	1.000		8.08%
(day)		4	77.00	70.00	69.00	1.00		1.670	1.535	8.08%	
KFIV	A	1	126.40	152.00	135.50	16.50	16.50	1.000	0.650	35.00%	35.00%
(night)		3		0.00	0.00	0.00		1.000	1.000		
KFIV	A	2	126.40	-91.50	-38.00	53.50	53.50	0.345	0.570	65.22%	65.22%
(day)		3		0.00	0.00	0.00		1.000	1.000		
KOQT	A	1	80.00	0.00	0.00	0.00	0.00	1.000	1.000		0.00%
(night)		3		-96.50	-96.50	0.00		0.680	0.680	0.00%	
KOQT	A	1	80.00	0.00	0.00	0.00	0.00	1.000	1.000		0.00%
(day)		2		-46.00	-46.00	0.00		0.810	0.810	0.00%	
WGUL	A,D	1	88.10	0.00	0.00	0.00	8.50	1.000	1.000		27.49%
(night)		2		88.00	79.50	8.50		0.684	0.872	27.49%	
WORD	C,D	1	96.60	0.00	0.00	0.00	104.80	1.000	1.000		54.83%
(day)		2	79.90	113.80	9.00	104.80		0.704	1.090	54.83%	
WLUP	C,D	1	179.00	-130.00	-134.50	4.50	4.50	0.400	0.408	2.00%	2.00%
(day)		2	161.00	0.00	0.00	0.00		1.000	1.000		
KWAM	C,D	2	181.20	45.70	-55.00	100.70	100.70	1.539	2.770	180.00%	180.00%
(night)		3	79.70	0.00	0.00	0.00		1.000	1.000		
KWAM	C,D	1	72.50	0.00	0.00	0.00	0.50	1.000	1.000		3.08%
(day)		2	181.20	12.50	12.00	0.50		1.300	1.340	3.08%	
KITA	A	1	98.00	0.00	0.00	0.00	0.00	1.000	1.000	0.00%	0.00%
(night)		2		-49.00	-49.00	0.00		1.000	1.000		
WXRA	A	1	94.40	-85.00	-84.00	1.00	1.00	0.781	0.720	7.80%	7.80%
(night)		2		0.00	0.00	0.00		1.000	1.000		
WBXR	A	1	81.80	0.00	0.00	0.00	2.00	1.000	1.000		1.33%
(day)		2		-150.00	-148.00	2.00		0.750	0.740	1.33%	
KRLD	A	1	187.50	0.00	0.00	0.00	0.50	1.000	1.000		26.71%
(night)		2		-86.50	-86.00	0.50		0.730	0.925	26.71%	

STATION CALL	ARRAY NOTE*	TOWER NUMBER	TOWER HEIGHT	PHASE DATA (DEGREES)				FIELD DATA			
				THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE	THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE
WBZK (day)	A	1	90.00	0.00	0.00	0.00	0.00	1.000	1.000		1.54%
		2		38.00	38.00	0.00		1.950	1.920	1.54%	
WANN (day)	A	1	96.00	0.00	0.00	0.00	7.00	1.000	1.000		17.92%
		2		-52.00	-45.00	7.00		0.653	0.770	17.92%	
KBFW (night)	A	1	85.10	-95.00	-95.00	0.00	0.00	0.750	0.760	1.33%	1.33%
		2		0.00	0.00	0.00		1.000	1.000		
WCHQ (day)	A	1	99.50	0.00	0.00	0.00	8.00	1.000	1.000		10.34%
		2		0.00	-8.00	8.00		0.580	0.520	10.34%	
KLOH (night)	A	1	88.40	0.00	0.00	0.00	17.00	1.000	1.000		33.33%
		2		-150.00	-167.00	17.00		0.600	0.400	33.33%	
KLOH (day)	A	1	88.40	0.00	0.00	0.00	2.00	1.000	1.000		2.27%
		2		40.00	38.00	2.00		0.880	0.860	2.27%	
KBEC (night)	A	1	81.40	0.00	0.00	0.00	0.00	1.000	1.000		4.17%
		2		-92.00	-92.00	0.00		0.720	0.750	4.17%	
WBOW (night)	B	1	59.50	-137.50	-138.00	0.50	0.50	0.400	0.590	47.50%	47.50%
		2		0.00	0.00	0.00		1.000	1.000		
WNTY (day&CH)	B	1	90.00	0.00	0.00	0.00	9.00	0.750	0.710	5.33%	5.33%
		2		114.00	105.00	9.00		1.000	1.000		
KIMM (night)	C	1	89.20	0.00	0.00	0.00	2.50	0.962	0.650	32.43%	32.43%
		2	63.10	16.50	14.00	2.50		1.000	1.000		
KISN (day&night)	C	1	77.20	0.00	0.00	0.00	0.00	1.000	1.000		6.45%
		2	77.20	31.60	31.60	0.00		1.240	1.160	6.45%	
KDFT (day)	C	1	74.30	0.00	0.00	0.00	0.00	1.000	1.000		0.36%
		2	74.30	-132.00	-132.00	0.00		0.833	0.830	0.36%	
WCRV (night)	C	1	50.00	0.00	0.00	0.00	1.50	1.000	1.000		5.29%
		2	90.00	139.00	140.50	1.50		0.680	0.644	5.29%	
WAYR (day)	C	1	99.60	0.00	0.00	0.00	0.40	1.000	1.000		30.23%
		2	99.60	-98.60	-99.00	0.40		0.645	0.840	30.23%	
KIJN (day)	C	1	90.00	0.00	0.00	0.00	6.00	1.000	1.000		4.23%
		2	90.00	-98.50	-92.50	6.00		0.710	0.680	4.23%	
WMUF (CH&day)	C	1	89.60	0.00	0.00	0.00	2.00	1.000	1.000		22.86%
		2	89.60	25.00	27.00	2.00		0.700	0.860	22.86%	
KSIV (night)	C	1	90.00	0.00	0.00	0.00	23.80	1.000	1.000		63.57%
		2	50.00	-116.00	-92.20	23.80		2.273	1.445	63.57%	
KSUD (night)	C	1	72.10	0.00	0.00	0.00	9.60	1.000	1.000		15.23%
		2	60.00	143.10	133.50	9.60		1.280	1.085	15.23%	
WPIE (night)	C	1	234.00	0.00	0.00	0.00	24.00	1.000	1.000		5.00%
		2	234.00	28.00	52.00	24.00		1.000	0.950	5.00%	
WPIE (day)	C	1	234.00	0.00	0.00	0.00	5.00	1.000	1.000		17.00%
		2	234.00	-130.00	-135.00	5.00		0.500	0.415	17.00%	
WVOK (night)	C	1	136.30	-150.00	-150.00	0.00	0.00	1.000	0.308	69.20%	69.20%
		2	68.20	0.00	0.00	0.00		1.000	1.000		

2-TOWER SAMPLE POPULATION

STATION CALL	ARRAY NOTE*	TOWER NUMBER	TOWER HEIGHT	PHASE DATA (DEGREES)				FIELD DATA			
				THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE	THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE
WRBK (day)	C	1	80.80	0.00	0.00	0.00	7.10	1.000	1.000		9.77%
		2	80.80	-28.90	-36.00	7.10		0.870	0.955	9.77%	
KBIF (night)	C	1	130.00	-94.00	-9.50	84.50	84.50	0.830	0.110	86.75%	86.75%
		2	64.20	0.00	0.00	0.00		1.000	1.000		
WAEC (night)	A,D	1	78.60	0.00	0.00	0.00	2.90	1.000	1.000		5.06%
		2		30.00	27.10	2.90		0.850	0.807	5.06%	
WCHT (night)	A,D	1	86.00	-135.00	-135.00	0.00	0.00	0.740	0.640	13.51%	13.51%
		2		0.00	0.00	0.00		1.000	1.000		
WCHT (day)	A,D	1	86.00	-135.00	-135.00	0.00	0.00	0.740	0.660	10.81%	10.81%
		2		0.00	0.00	0.00		1.000	1.000		
WAEB (day)	A,D	1	86.50	0.00	0.00	0.00	20.00	0.625	0.820	31.20%	31.20%
		2		73.00	53.00	20.00		1.000	1.000		
WBET (night)	C,D	1	156.00	0.00	0.00	0.00	14.00	1.000	1.000		0.00%
		2	122.00	110.00	124.00	14.00		0.880	0.880	0.00%	
WQSI (day)	C,D	1	100.00	0.00	0.00	0.00	1.00	1.000	1.000		5.62%
		2	100.00	122.00	121.00	1.00		0.890	0.940	5.62%	
KBOP (day)	C,D	1	185.90	0.00	0.00	0.00	14.00	1.000	1.000		15.70%
		2	90.00	17.00	31.00	14.00		0.847	0.980	15.70%	
WXVX (day)	C,D	1	88.40	110.00	100.00	10.00	10.00	0.752	0.550	26.86%	26.86%
		2	59.20	0.00	0.00	0.00		1.000	1.000		
WCBX (night)	C,D	1	88.20	135.00	130.70	4.30	4.30	0.420	0.498	18.57%	18.57%
		2	80.70	0.00	0.00	0.00		1.000	1.000		
WJTZ (night)	C,D	1	105.40	0.00	0.00	0.00	10.00	1.000	1.000		66.70%
		2	44.40	-126.00	-136.00	10.00		2.114	1.410	66.70%	
WJJQ (day)	C,D	1	88.90	123.62	110.50	13.12	13.12	0.699	0.695	0.57%	0.57%
		2	59.30	0.00	0.00	0.00		1.000	1.000		
WAMW (day)	C,D	1	60.00	0.00	0.00	0.00	81.50	1.000	1.000		51.60%
		2	186.10	-131.00	147.50	81.50		0.752	0.388	51.60%	

* ARRAY NOTE:
A   equal height, guyed towers, series excited
B   equal height, self-supporting towers, series excited
C   unequal heights, multiple type towers, top-loaded, folded unipoles or shunt excited
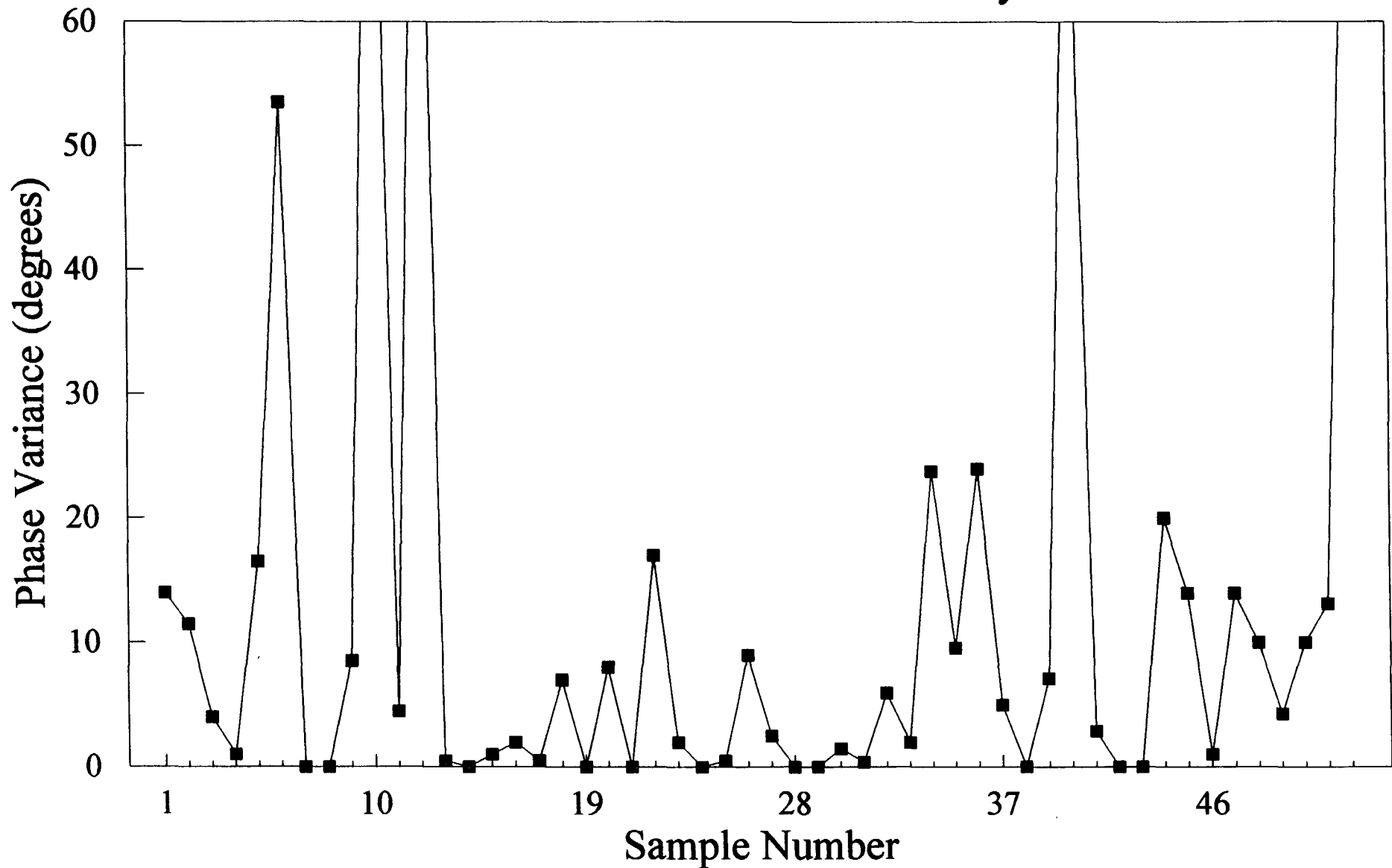D   antenna(s) from other services mounted on tower(s)

Field Variance
In a 2-Tower Directional Array

Variance for all towers other than the reference tower in the array are represented above.

Phase Variance
In a 2-Tower Directional Array

Variance for all towers other than the reference tower are represented above

STATION CALL	ARRAY NOTE*	TOWER NUMBER	TOWER HEIGHT	PHASE DATA (DEGREES)				FIELD DATA			
				THEO-RETICAL	OPER ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE	THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE
KVON (night)	C	1	106.00	-17.00	111.00	128.00	101.50	0.900	0.920	2.22%	7.36%
		2		0.00	0.00	0.00		0.800	0.700	12.50%	
		3		-139.00	146.00	75.00		1.000	1.000		
KRIO (day)	A	1	84.60	0.00	0.00	0.00	12.25	1.000	1.000		8.79%
		2		138.00	137.50	0.50		0.640	0.730	14.06%	
		4		192.00	168.00	24.00		0.710	0.735	3.52%	
WFGW (night)	A	1	90.00	85.00	65.90	19.10	19.50	1.180	1.624	37.63%	35.28%
		2		0.00	0.00	0.00		1.000	1.000		
		4		70.00	50.10	19.90		1.430	1.901	32.94%	
WFGW (day)	A	1	90.00	-50.00	-51.10	1.10	2.00	0.258	0.320	24.03%	18.62%
		2		0.00	0.00	0.00		1.000	1.000		
		3		50.00	47.10	2.90		0.969	0.841	13.21%	
KNTR (day)	A	1	80.00	-50.80	-50.80	0.00	0.00	0.724	0.690	4.70%	4.19%
		2		0.00	0.00	0.00		1.000	1.000		
		3		52.20	52.20	0.00		0.353	0.340	3.68%	
KSEV (night)	C	1	90.00	0.00	0.00	0.00	2.25	1.000	1.000		10.81%
		2	90.00	-105.90	-107.50	1.60		0.509	0.455	10.61%	
		3	90.00	105.90	103.00	2.90		0.509	0.565	11.00%	
KSEV (day)	C	2	90.00	-94.10	-30.50	63.60	63.50	0.930	0.670	27.96%	30.04%
		3	90.00	-55.90	7.50	63.40		0.663	0.450	32.13%	
		4	71.70	0.00	0.00	0.00		1.000	1.000		
WADN (night)	A,D	1	80.40	108.70	4.80	103.90	87.90	0.620	0.523	15.65%	9.45%
		2		0.00	0.00	0.00		1.000	1.000		
		3		-109.70	-37.80	71.90		0.430	0.416	3.26%	
WDPN (day)	C,D	1	96.00	0.00	0.00	0.00	4.00	1.000	1.000		5.65%
		2	96.00	145.00	152.00	7.00		0.620	0.590	4.84%	
		3	96.00	-170.00	-169.00	1.00		0.620	0.660	6.45%	
WWMO (night)	A	1	88.20	-108.80	-113.50	4.70	3.45	0.509	0.490	3.73%	9.82%
		2		0.00	0.00	0.00		1.000	1.000		
		3		108.80	111.00	2.20		0.509	0.590	15.91%	
WWMO (day)	A	1	88.20	0.00	0.00	0.00	0.50	1.000	1.000		2.78%
		2		130.00	131.00	1.00		0.900	0.886	1.56%	
		3		-100.00	-100.00	0.00		0.450	0.468	4.00%	
WHYZ (night)	A	1	110.00	142.00	140.00	2.00	1.25	0.700	0.660	5.71%	4.18%
		2		0.00	0.00	0.00		1.000	1.000		
		3		-136.50	-136.00	0.50		0.565	0.580	2.65%	

3-TOWER SAMPLE POPULATION

STATION CALL	ARRAY NOTE*	TOWER NUMBER	TOWER HEIGHT	PHASE DATA (DEGREES)				FIELD DATA			
				THEO-RETICAL	OPER ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE	THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE
WHYZ (day)	A	1	110.00	153.10	152.00	1.10	1.75	0.500	0.575	15.00%	12.00%
		2		0.00	0.00	0.00		1.000	1.000		
		3		-164.90	-162.50	2.40		0.500	0.545	9.00%	
KAFY (night)	A	1	90.00	0.00	0.00	0.00	24.25	1.000	1.000		30.00%
		2		-130.00	-155.00	25.00		0.603	0.448	25.70%	
		3		151.50	128.00	23.50		0.481	0.646	34.30%	
KAFY (day)	A	1	90.00	0.00	0.00	0.00	3.50	1.000	1.000		19.96%
		2		-140.00	-142.00	2.00		0.300	0.365	21.67%	
		3		140.00	135.00	5.00		0.400	0.327	18.25%	
KLVS (day&night)	A	1	76.40	-122.00	-128.00	6.00	6.00	0.510	0.504	1.18%	1.18%
		2		0.00	0.00	0.00		1.000	1.000		
		3		134.00	128.00	6.00		0.510	0.504	1.18%	
WILC (night)	A	1	79.00	-168.50	-166.00	2.50	3.25	1.213	1.060	12.61%	10.45%
		2		0.00	0.00	0.00		1.000	1.000		
		3		168.00	172.00	4.00		0.785	0.850	8.28%	
WILC (day)	A	1	79.00	-68.50	-71.50	3.00	3.80	0.543	0.550	1.29%	10.97%
		2		0.00	0.00	0.00		1.000	1.000		
		3		72.40	77.00	4.60		0.547	0.660	20.66%	
KCCV (day)	A	1	90.00	-6.00	5.00	11.00	7.00	0.376	0.445	18.35%	12.84%
		2		0.00	0.00	0.00		1.000	1.000		
		3		13.00	16.00	3.00		0.968	1.039	7.33%	
KJOY (night)	A	1	93.60	78.80	19.50	59.30	70.10	0.350	0.404	15.43%	12.45%
		2		0.00	0.00	0.00		1.000	1.000		
		3		232.10	151.20	80.90		0.770	0.697	9.48%	
KFIT (day)	A	1	98.00	0.00	5.00	5.00	5.50	1.000	1.000		2.17%
		2		82.00	80.00	2.00		0.506	0.490	3.16%	
		3		-82.00	-86.00	4.00		0.506	0.500	1.19%	
KHPY (CH)	A	1	90.00	-143.50	-114.80	28.70	24.05	0.530	0.425	19.81%	16.66%
		2		-76.50	-57.10	19.40		0.555	0.480	13.51%	
		3		0.00	0.00	0.00		1.000	1.000		
KHPY (day)	A	1	90.00	0.00	0.00	0.00	26.35	1.000	1.000		27.83%
		2		45.00	85.20	40.20		0.920	0.543	40.98%	
		3		120.00	107.50	12.50		0.920	0.785	14.67%	
KBET (day&night)	A	1	80.40	-93.00	-121.00	28.00	18.50	0.450	0.350	22.22%	17.04%
		2		0.00	0.00	0.00		1.000	1.000		
		3		93.00	102.00	9.00		0.590	0.660	11.86%	

3-TOWER SAMPLE POPULATION

STATION CALL	ARRAY NOTE*	TOWER NUMBER	TOWER HEIGHT	PHASE DATA (DEGREES)				FIELD DATA			
				THEO-RETICAL	OPER ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE	THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE
KFIT (day)	A	1	98.00	0.00	0.00	0.00	3.00	1.000	1.000	0.00%	2.17%
		2		82.00	80.00	2.00		0.506	0.490	3.16%	
		3		-82.00	-86.00	4.00		0.506	0.500	1.19%	
KWNK (day&night)	A	1	90.00	0.00	0.00	0.00	97.00	1.000	1.000		6.56%
		2		-142.00	122.00	96.00		0.610	0.560	8.20%	
		3		132.00	34.00	98.00		0.610	0.640	4.92%	
KFMB (night)	B	1	87.60	-74.00	-52.10	21.90	19.20	0.240	0.711	196.25%	109.63%
		2		0.00	0.00	0.00		1.000	1.000		
		3		67.60	51.10	16.50		0.678	0.834	23.01%	
KTGE (night)	C	1	215.10	122.14	-120.20	117.66	138.26	0.619	1.020	64.78%	42.15%
		2	197.00	0.00	0.00	0.00		1.000	0.900	10.00%	
		3	215.10	-122.14	79.00	158.86		0.502	0.600	19.52%	
KTGE (day)	C	1	215.10	63.80	-69.00	132.80	107.75	0.336	0.700	108.33%	66.07%
		2	197.00	0.00	0.00	0.00		1.000	1.000		
		3	215.10	-52.10	30.60	82.70		0.420	0.320	23.81%	
WJMX (night)	C	1	180.00	-154.90	219.00	13.90	9.45	0.534	0.420	21.35%	15.67%
		2	88.80	0.00	0.00	0.00		1.000	1.000		
		3	88.80	140.00	135.00	5.00		0.700	0.770	10.00%	
WNAP (day)	C	1	95.50	54.39	49.00	5.39	3.50	1.040	1.010	2.88%	5.67%
		2	95.50	145.39	147.00	1.61		0.710	0.650	8.45%	
		3	74.30	0.00	0.00	0.00		1.000	1.000		
KQRS (night)	A,D	1	137.00	0.00	0.00	0.00	13.20	1.000	1.000		91.38%
		2	105.40	-150.90	-168.70	17.80		0.474	1.230	159.49%	
		3	105.40	172.70	164.10	8.60		0.752	0.927	23.27%	
WGUL (day)	A,D	1	88.10	0.00	0.00	0.00	6.60	1.000	1.000		11.02%
		2		156.20	150.00	6.20		0.517	0.570	10.25%	
		3		-109.00	-102.00	7.00		0.492	0.550	11.79%	
KCIS (night)	A,D	1	87.60	-141.50	-138.50	3.00	4.35	0.783	0.754	3.70%	4.01%
		2		0.00	0.00	0.00		1.000	1.000		
		3		151.00	145.30	5.70		0.324	0.338	4.32%	
KCVR (night)	A,D	1	90.00	0.00	0.00	0.00	8.70	1.000	1.000		58.82%
		2		-80.20	-73.30	6.90		0.930	0.948	1.94%	
		3		18.60	8.10	10.50		0.140	0.302	115.71%	
KCVR (day)	A,D	1	90.00	0.00	0.00	0.00	14.70	1.000	1.000		11.24%
		2		34.90	14.00	20.90		1.309	1.321	0.92%	
		3		-94.10	-102.60	8.50		1.308	1.026	21.56%	
WCAG (day&night)	A,D	1	79.20	0.00	0.00	0.00	3.25	1.000	1.000		13.38%
		2		-106.30	-104.00	2.30		0.420	0.458	9.05%	
		3		106.30	110.50	4.20		0.610	0.502	17.70%	

3-TOWER SAMPLE POPULATION
PAGE 4

STATION CALL	ARRAY NOTE*	TOWER NUMBER	TOWER HEIGHT	PHASE DATA (DEGREES)				FIELD DATA			
				THEO-RETICAL	OPER ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE	THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE
WORD (night)	C,D	1	96.60	0.00	0.00	0.00	122.95	1.000	1.000		53.61%
		2	79.90	156.40	56.00	100.40		0.775	1.030	32.90%	
		3	79.90	-156.50	-11.00	145.50		0.545	0.950	74.31%	
WKTR (day)	C,D	1	93.80	148.86	147.00	1.86	1.54	0.480	0.464	3.33%	1.89%
		2	93.80	0.00	0.00	0.00		1.000	1.000		
		3	93.80	-144.97	-146.20	1.23		0.670	0.667	0.45%	
WLUP (night)	C,D	1	179.00	-115.00	-132.50	17.50	16.75	0.230	0.500	117.39%	78.34%
		2	161.00	0.00	0.00	0.00		1.000	1.000		
		3	179.00	107.00	123.00	16.00		0.840	0.510	39.29%	
WBUD (night)	C,D	1	120.50	146.81	148.00	1.20	2.16	0.694	0.200	71.18%	37.47%
		2	84.10	0.00	0.00	0.00		1.000	1.000		
		3	89.60	-141.88	-145.00	3.12		0.558	0.579	3.76%	
WBUD (day)	C,D	1	120.50	177.94	170.00	7.94	4.15	0.563	0.115	79.57%	52.62%
		2	84.10	0.00	0.00	0.00		1.000	1.000		
		3	89.60	178.13	178.50	0.37		0.565	0.420	25.66%	
KBNA (night)	C,D	1	117.00	0.00	0.00	0.00	1.50	1.000	1.000		195.31%
		2	84.00	-150.00	-149.00	1.00		0.640	1.920	200.00%	
		3	84.00	-150.00	-152.00	2.00		0.640	1.860	190.63%	

* ARRAY NOTE: A   equal height, guyed towers, series excited
                        B   equal height, self-supporting towers, series excited
                        C   unequal heights, multiple type towers, top-loaded, folded unipoles or shunt excited
                        D   antenna(s) from other services mounted on tower(s)
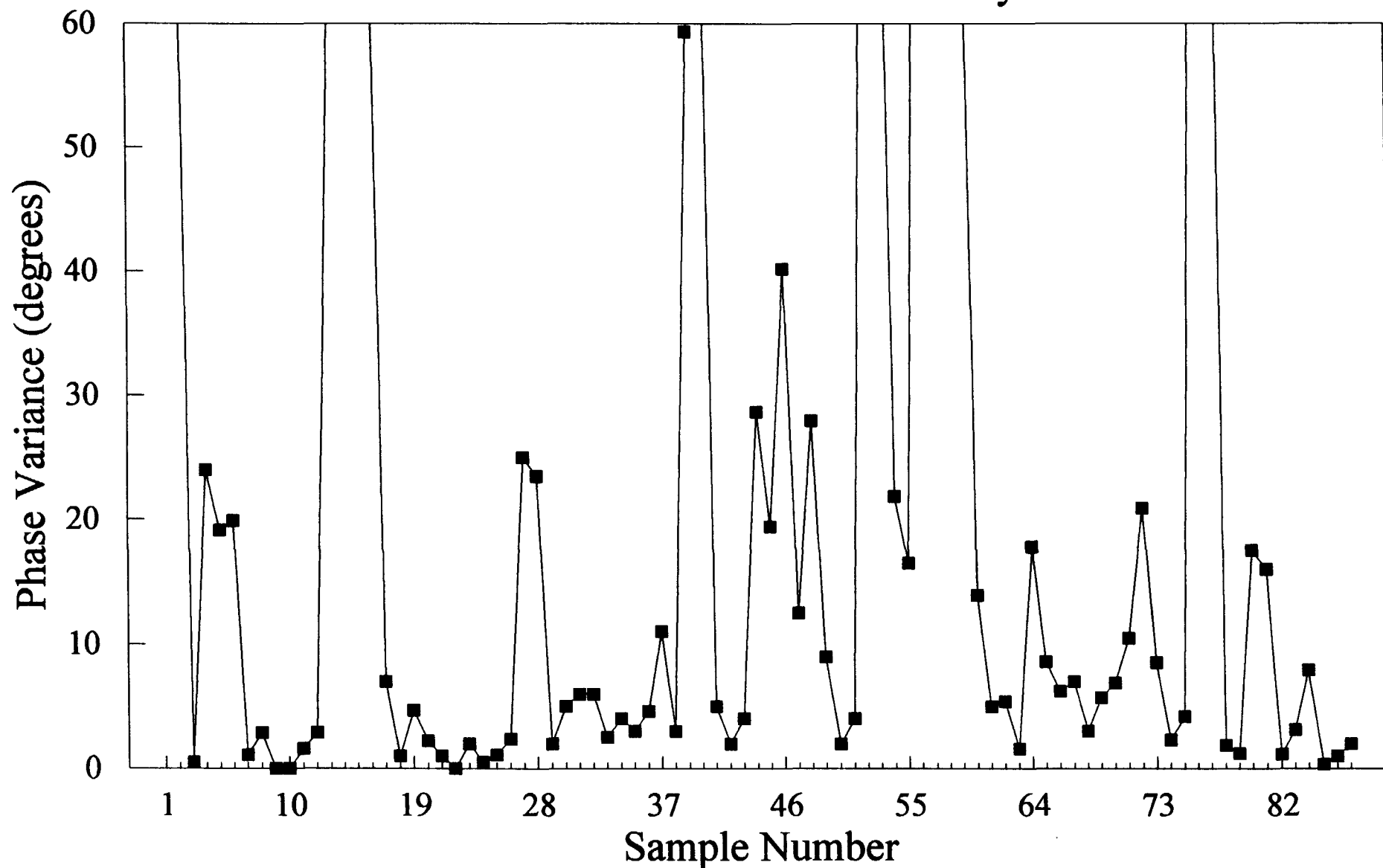
Field Variance
In a 3-Tower Directional Array
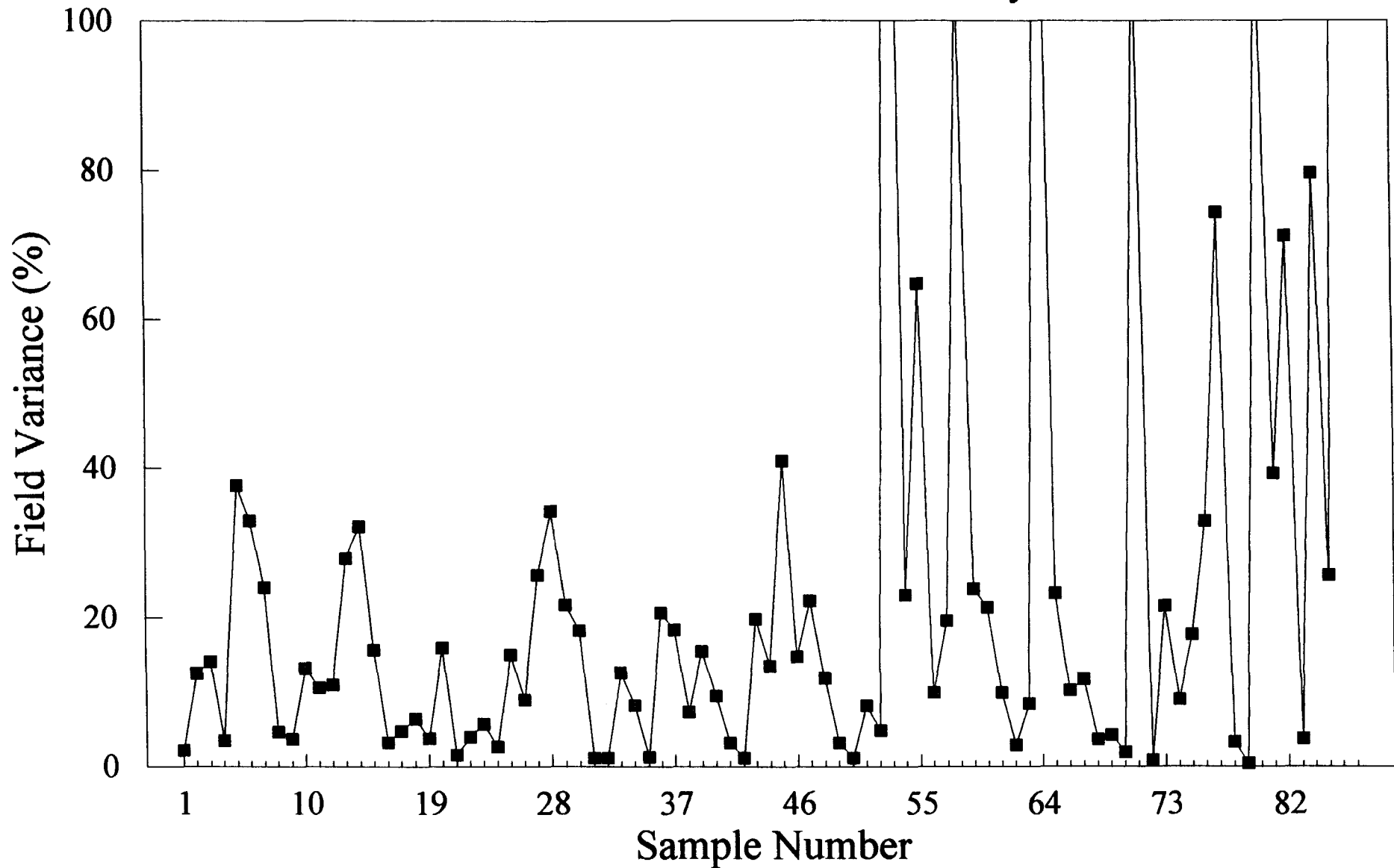
Variance for all towers other than the reference tower in the array are represented above.

Phase Variance
In a 3-Tower Directional Array

Variance for all towers other than the reference tower are represented above

4-TOWER SAMPLE POPULATION

STATION CALL	ARRAY NOTE*	TOWER NUMBER	TOWER HEIGHT	PHASE DATA (DEGREES)				FIELD DATA			
				THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE	THEO-RETICAL	OPER-ATIONAL	TOWER VARIANCE	AVERAGE ARRAY VARIANCE
KVON (day)	C	1	106.00	0.00	0.00	0.00	106.77	1.000	1.000		4.97%
		2		101.60	-56.00	157.60		0.950	0.860	9.47%	
		3		-0.40	139.00	139.40		0.910	0.930	2.20%	
		4		91.30	68.00	23.30		0.620	0.640	3.23%	
KRIO (night)	A	1	84.60	0.00	0.00	0.00	0.37	1.000	1.000		14.04%
		2		143.70	143.00	0.70		0.776	0.887	14.30%	
		3		-178.90	-179.00	0.10		0.415	0.465	12.05%	
		4		144.70	145.00	0.30		0.622	0.720	15.76%	
KCBS (night)	A	1	135.50	0.00	0.00	0.00	4.53	1.000	1.000		17.94%
		2		-110.70	-116.00	5.30		0.933	1.070	14.68%	
		3		-125.50	-130.50	5.00		0.766	0.890	16.19%	
		4		-2.70	-6.00	3.30		0.880	1.082	22.95%	
KCBS (day)	A	1	135.50	0.00	0.00	0.00	6.33	1.000	1.000		21.75%
		2		-116.00	-119.50	3.50		0.600	0.560	6.67%	
		3		-120.00	-128.50	8.50		0.210	0.290	38.10%	
		4		-4.00	3.00	7.00		0.400	0.482	20.50%	
WKTP (night)	A	1	81.50	-156.10	-158.50	2.40	7.03	0.463	0.371	19.87%	19.73%
		2		0.00	0.00	0.00		1.000	1.000		
		3		-203.50	151.00	5.50		0.926	1.108	19.65%	
		4		-49.80	-63.00	13.20		0.361	0.432	19.67%	
WKTP (day)	A	1	81.50	-156.10	-158.50	2.40	7.00	0.463	0.385	16.85%	20.37%
		2		0.00	0.00	0.00		1.000	1.000		
		3		156.50	151.20	5.30		0.926	1.128	21.81%	
		4		-49.80	-63.10	13.30		0.361	0.442	22.44%	
WSML (night)	A	1	88.00	127.00	127.00	0.00	42.67	0.400	0.390	2.50%	2.13%
		2		-116.00	-116.00	0.00		1.000	1.000		
		3		0.00	0.00	0.00		1.000	1.014	1.40%	
		4		-116.00	116.00	128.00		0.400	0.410	2.50%	
KIXL (day)	A	1	85.20	132.70	133.00	0.30	18.60	1.000	1.000		10.60%
		2		0.00	0.00	0.00		1.830	1.957	6.94%	
		3		-124.50	-116.00	8.50		1.090	1.217	11.65%	
		4		-187.00	-140.00	47.00		0.250	0.217	13.20%	
WNOG (night)	A	1	71.60	-91.00	-86.50	4.50	2.83	1.870	0.520	72.19%	48.39%
		2		-67.00	-65.00	2.00		1.030	0.297	71.17%	
		3		0.00	0.00	0.00		1.000	1.000		
		4		24.00	22.00	2.00		0.550	0.540	1.82%	